Neutron Imaging Study of The Water Transport Mechanism In a Working Fuel Cell

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This presentation does not contain any proprietary or confidential information

Objective

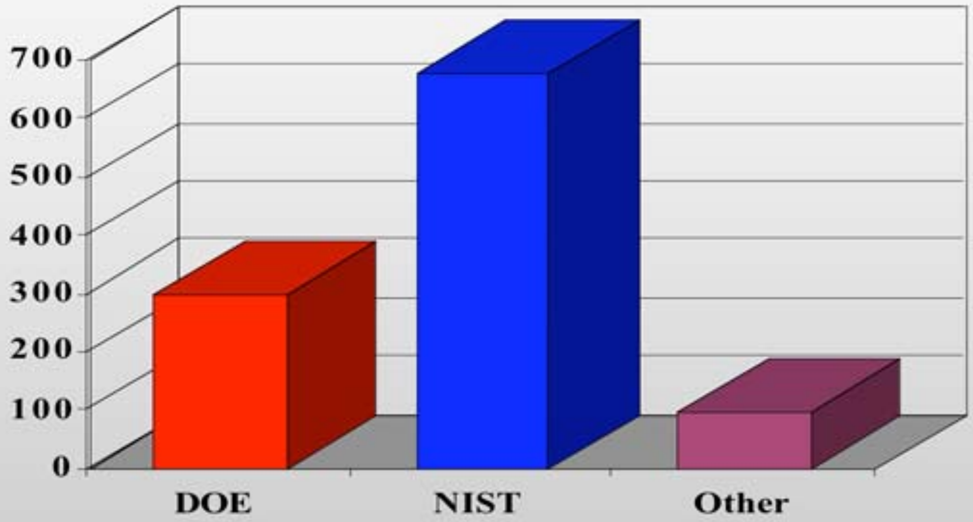
Project Objectives

- To assist DOE in the development of effective neutron imaging based non-destructive diagnostics tool for characterization of water transport in PEM fuel cells.

FY 2003 Objectives

- Provide research and testing infrastructure enabling fuel industry to test commercial grade fuel cell flow field designs. Provide training to industry enabling them use the imaging facility independently
- Transfer data interpretation and analysis algorithms/techniques to industry, enabling them to utilize research information more effectively and independently

Budget



FY 2003

Total : 1077K (100%)

DOE : 300K (27 %)

NIST : 677K (62%)

Other : 100K (11%)

Technical Barriers and Targets

DOE Technical Barriers for Fuel Cell Components

- **- R. Thermal and Water Management**. …..Water management techniques to address humidification requirements and maintain water balance are required.
- **-P. Component Durability** MEA structural integrity and morphology

Approach

- Develop high resolution neutron imaging capability
- Develop capability for accurate data interpretation and quantitative image processing
- Develop infrastructure for testing fuel cells
- Test fuel cells with partnership with industries and academia. Evaluate impacts of research.
- Transfer technology to industry as it matures
- Get feed back from users and seek opportunities for future technical breakthroughs

Project Safety

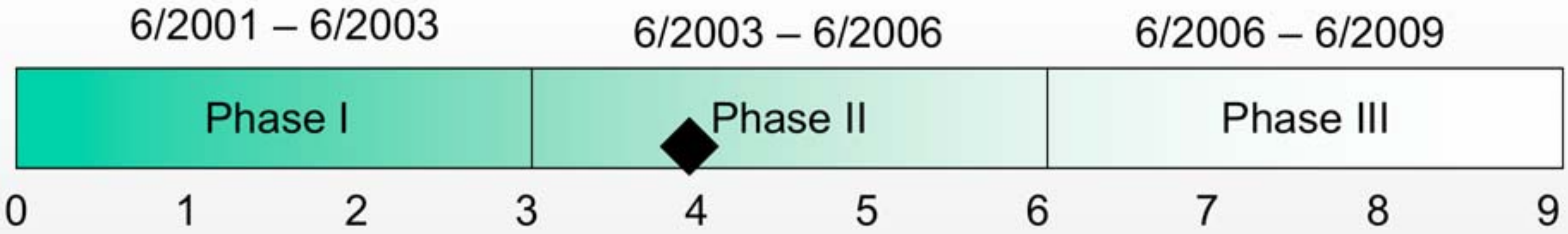
All aspects of the instrument design and operation are rigorously reviewed by NIST neutron source Safety Evaluation Committee (SEC) and Hazard Review Committee. Issues reviewed include among others -

- Hazard related to Hydrogen transport. storage and venting
- Possible radiation and other hazard to users
- Alarm system and response procedure in the event of instrument and safety mechanism malfunction
- Chain of command for after hour emergencies

As a consequence of these safety reviews, we do not use hydrogen storage bottles for experiments but use on demand hydrogen generators instead.

Safety is the number one priority at NIST

Project Timeline



- **Phase I**
  - Facility beam line chosen and developed.
  - Facility started operation.

- **Phase II**
  - Users of facility taking data.
  - Begin publishing results.
  - Develop 3-D methods, high resolution (5-15 micro-meter) real time imaging (30 fps). Develop advanced fuel cell testing infrastructure.
  - Extend measurements to full stack

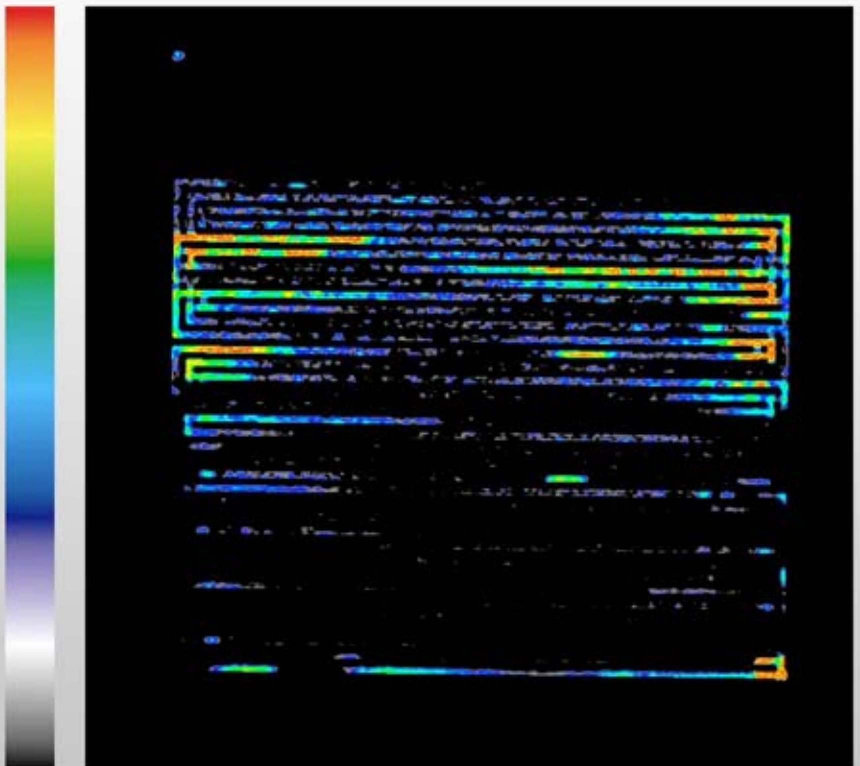
- **Phase III**
  - Continue to provide advanced measurement and testing capability to fuel cell industry with hydrogen metrology issues.

Technical Accomplishments

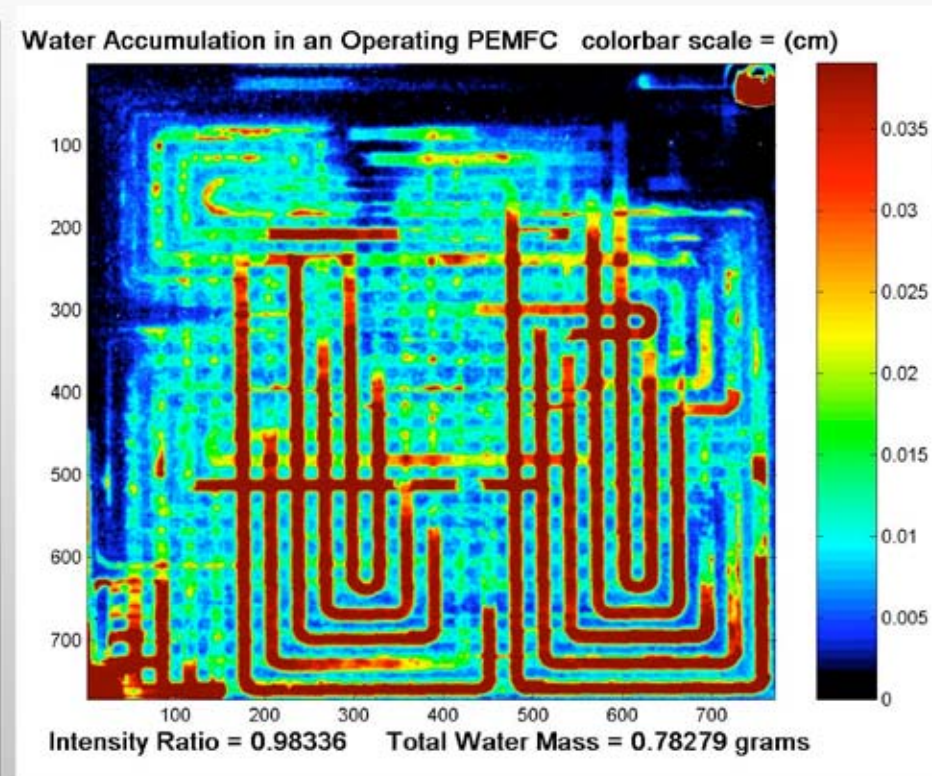
- Finished constructing neutron imaging station for fuel cell research
- In collaboration with industrial partners, studied Flow Channel designs, impact on membrane water transport and power output
- Developed capability to quantify water distribution and content with high accuracy
- Published one major article and two more are in prepartion

Total Water Accumulation

High



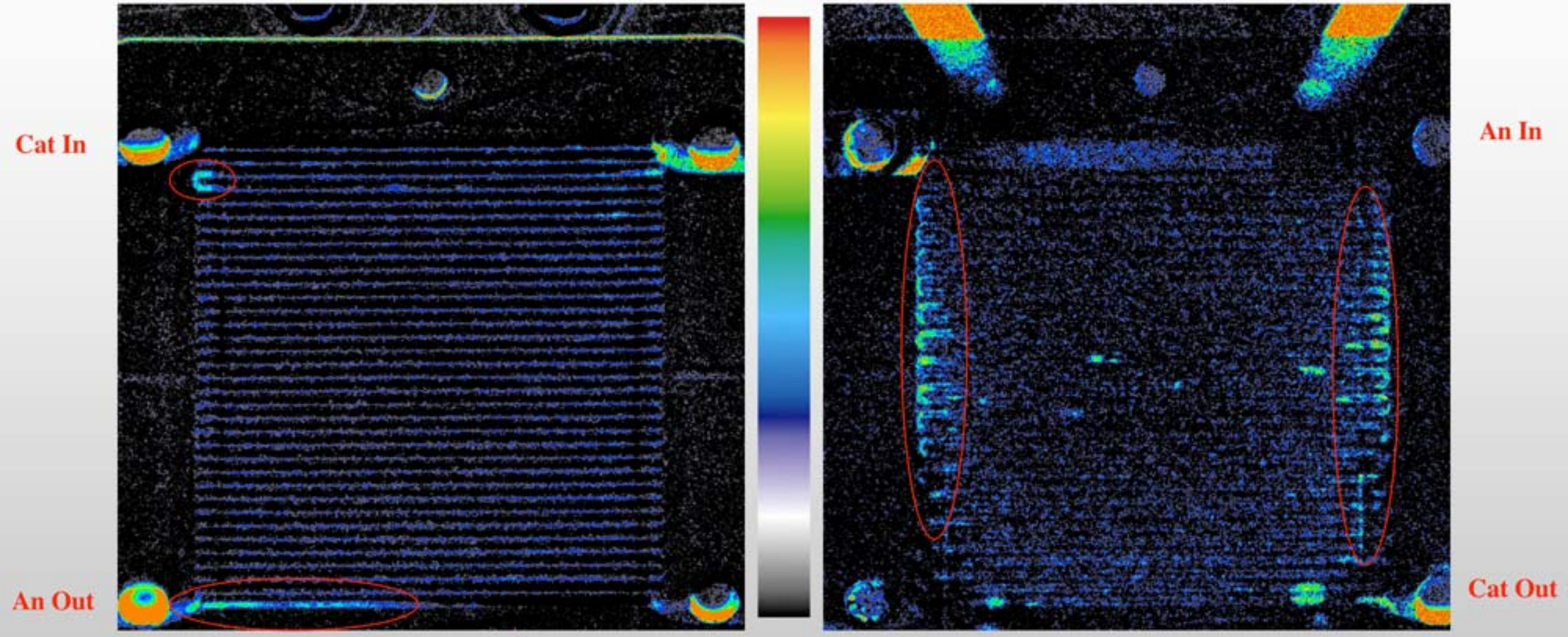
Low



Water detection sensitivity is better than 1 μg

Fuel Cell A

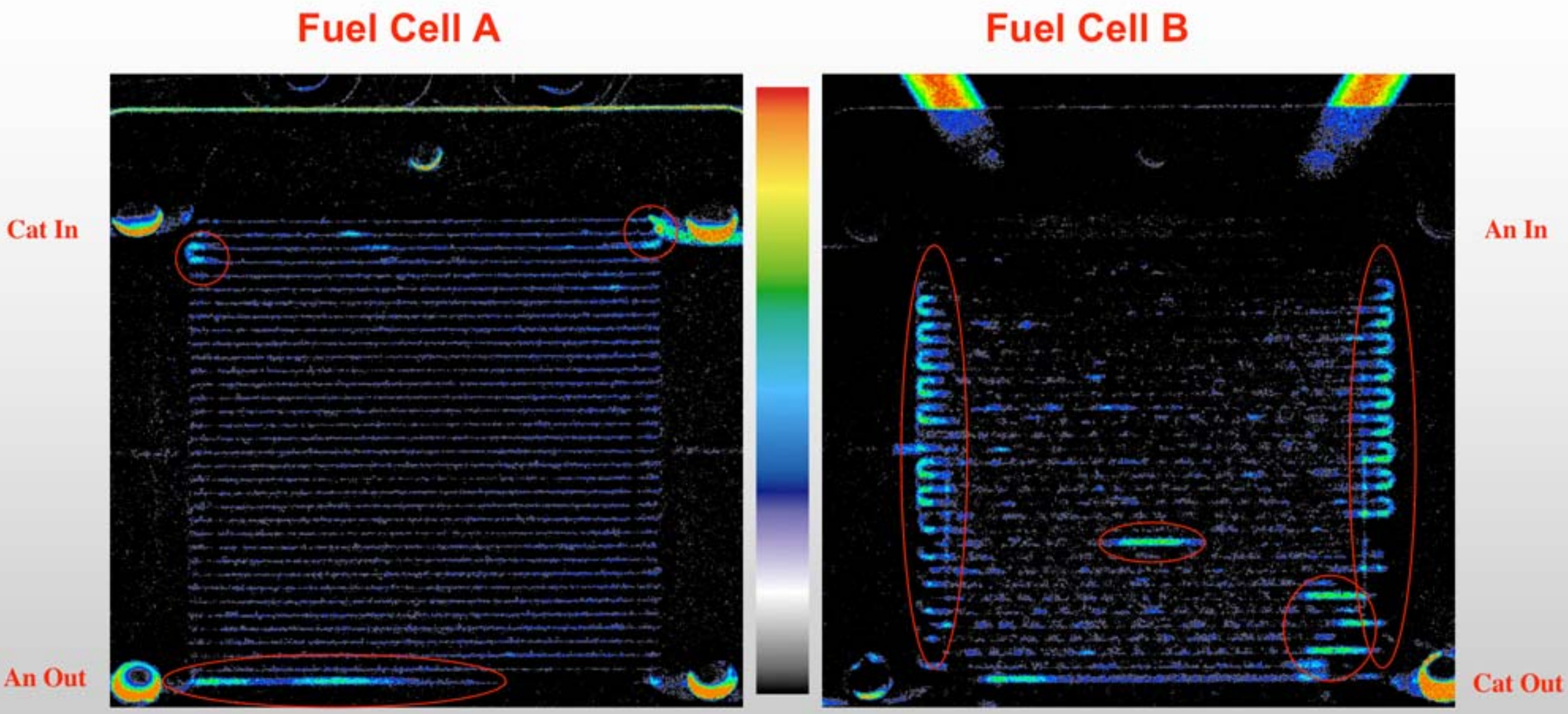
Fuel Cell B



0.6A/cm^2, 60/60/60°C cell/anode/cathode; **1.2/2.0** H_2 /Air

Spotty water thin films ⇩ Open channels

Some water droplets ⇩ Minor flooding at U-turns



0.4 A/cm^2, 60/60/60^{o}C cell/anode/cathode; **1.2/2.0** H_2 /Air

Spotty water thin films

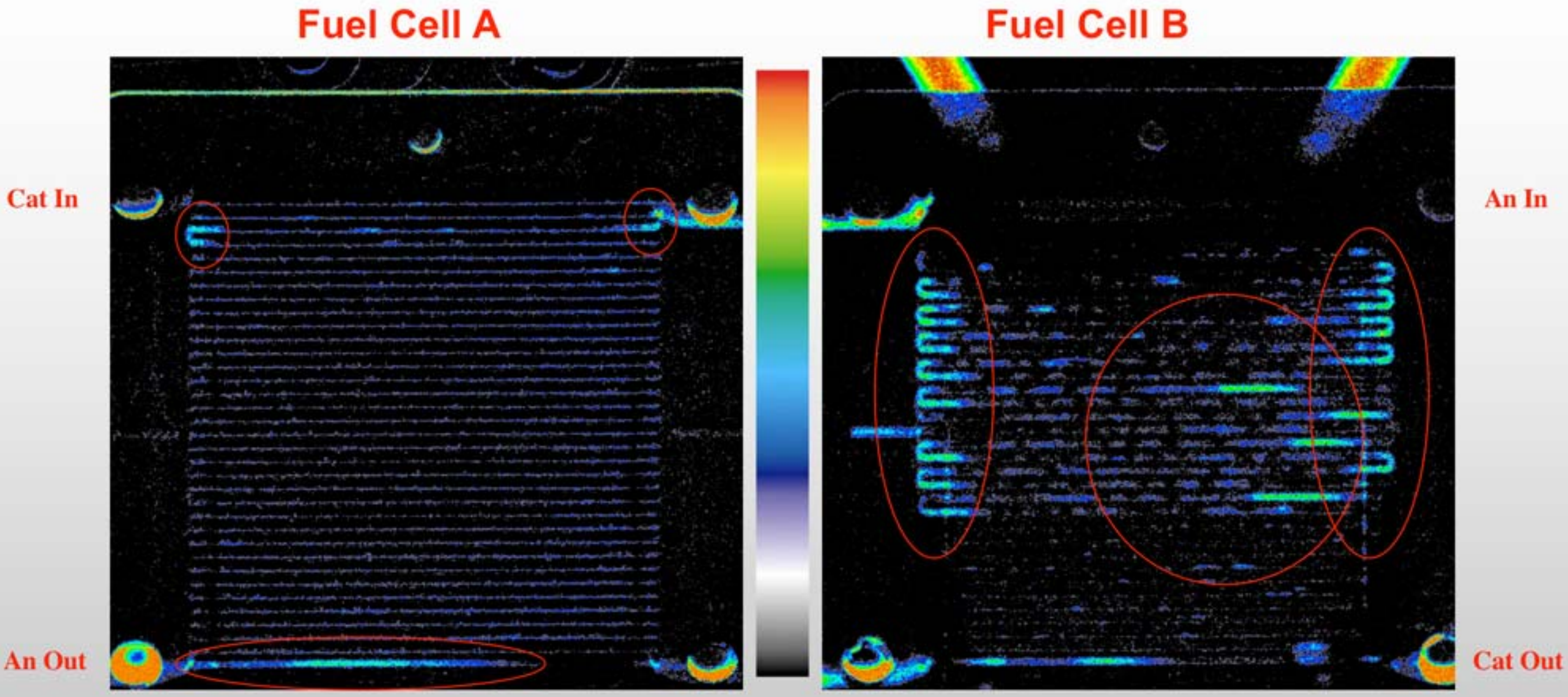
⇩

Open channels

Water droplets & thin films

⇩

Flooding at U-turns



0.2 A/cm^2, 60/60/60^{o}C cell/anode/cathode; **1.2/2.0** H_2 /Air

Spotty water thin films

⇩

Open channels

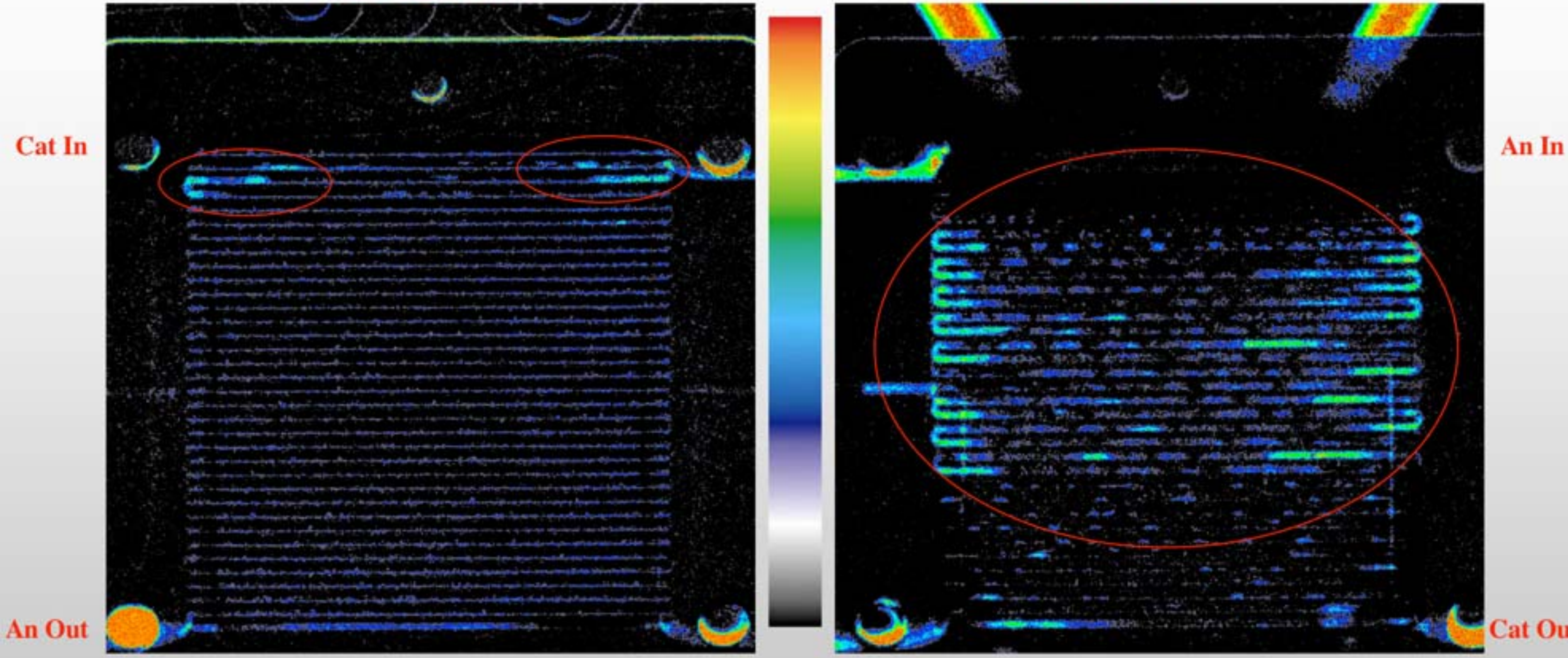
Water droplets blocked channel

⇩

Major flooding at U-turns

Fuel Cell A

Fuel Cell B



0.1 A/cm², 60/60/60°C cell/anode/cathode; **1.2/2.0** H_2 /Air

Some water thin films

⇩

Reactants/water flow smoothly

Water columns blocked channel

⇩

Severe flooding at U-turns

Summary of Observations

- Fuel Cell A showed excellent water management capability under normal operating conditions for the current density range from 0.1 to 0.6 A/cm^2. It worked very well even with 5^oC supersaturated reactants.
- Fuel Cell B showed serious flooding at low current density and had significant water droplet blockages even at high current density under normal condition.

Interactions and Collaborations

- General Motors
- PlugPower
- DuPont
- NRL
- University of Delaware *
- University of Miami *
- Daimler Chrysler *

Responses to Previous Year Reviewers' Comments

- More University Collaboration

  We have initiated contacts with university of Miami and University of Delaware

- Technology development should be a priority

  Technology development is a very high priority for us. We are constantly improving temporal and spatial resolutions. We have made very significant progress in image processing of complex structures and quantification of the data.

Future Work

- Improve spatial resolution to better than 25 micro-meter the near future and then ultimately to better than 10 micro-meter’
- Improve temporal resolution to 30 frames per second for large area imaging
- Study of full size (for automobiles) fuel cell stack
- Develop high resolution 3-D non-rotating coded aperture imaging for real time layered inspection of MEA water transport and morphology
- Publications of results
- Improved interactions with academic institutions